



USAFA *Discovery* is published quarterly by the faculty of the US Air Force Academy (USAFA). It contains reports on USAFA cadet and faculty research, a complete list of current USAFA research points of contact, and a summary of recent awards and publications. All written material contained within reflects the opinions of the authors and editors and does not necessarily reflect current US Air Force or USAFA policy.

Cadets Begin Fabrication of Satellite for Launch

Cadets in the class of 1999 are turning their design into reality as they build the Academy's first free-flying satellite, FalconSat-I. The spacecraft is scheduled for launch in September 1999. The cadet teams completed critical design milestones in December and have begun the hardware fabrication, testing, and integration phases. The teams are also responsible for the scheduling and budgetary phases of the mission.

Faculty and cadets from several departments are critical to the success of the FalconSat-I project. Cadets majoring in Astronautics, Computer Science, Electrical Engineering, Space Operations, Engineering Mechanics, Management, and Physics are enrolled in the Small Spacecraft Engineering course (Engr 434) that will fulfill the goal of delivering the satellite for launch. Faculty mentors from each of these departments guide the cadets' progress toward this achievement.

Spacecraft hardware and ground test equipment are fabricated in the Astronautics laboratory located in the Consolidated Education Training Facility (CETF). The cadets are organized into teams dedicated to completing a portion of the project. The teams are managed through a cadet management structure. The teams include systems engineering, structures, communications, attitude determination and control, software and data handling, electrical power, launch vehicle integration, ground station, and testing. Fig. 1 shows cadets working with the flight hardware.

Plans for the spring semester include completing fabrication of the major satellite subsystems in February. The subsystems will be integrated together and tested during March and April. Final delivery of the satellite is planned for May 1999. The spacecraft will be fitted to the launch stack and mated to the launch vehicle throughout the summer months.

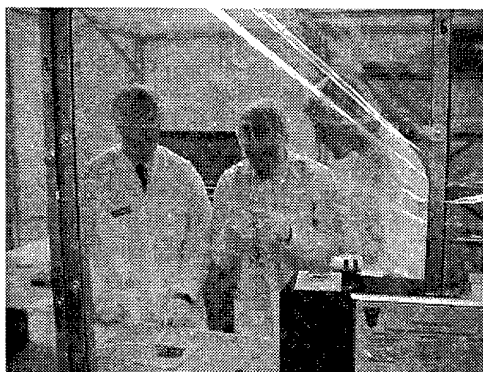


Fig. 1. Spacecraft Fabrication Activity in CETF. C1Cs Jim Taggart, Justin Hendricks, and Scott Karl (left to right) prepare to test the communications system modem in the small satellite clean room.

Once on orbit, cadets will operate the spacecraft in the new satellite ground station. Installation of the antennas on the roof of the CETF, as well as the ground station equipment has been completed. Cadets majoring in computer science are developing the ground station software. The software will be used to operate the satellite and receive science data and health and status information when the spacecraft is in view of the Academy. Cadets are developing the software through their course work in Software Engineering I & II (Comp Sci 453/454).

What will the spacecraft actually do? FalconSat-1 is a small satellite carrying the Charging Hazards and Wake Studies-Long Duration (CHAWS-LD) experiment. The purpose of the mission is to determine the effects of spacecraft charging in a low-earth orbit over a time period of at least six months. The primary objectives of the mission are to (1) Provide data that will allow scientists to analyze the effects of charging on spacecraft in low-earth orbit over an extended time period; (2) Validate FalconSat-1 system design by transmitting telemetry data, gathered by the different subsystems of the spacecraft bus, to the mission control center; (3) Provide a flight experience with new computer hardware and

software developed for the program; (4) Provide a ground station test bed for education and training purposes and allow cadets to gain hands on experience in space operations.

How long will FalconSat-1 remain aloft? The cadets plan to collect science data for about a year after launch, and will operate the spacecraft as long as possible. The orbit of the spacecraft will decay over time, and the satellite will burn up in the upper atmosphere in roughly 17 years.

What are the potential military applications of the satellite? The FalconSat-1 mission addresses military requirements for space-based environmental sensors and questions about spacecraft charging for the design of future DoD satellites. Previous DoD satellites have been killed by this effect--sensitive electronics were destroyed by spurious voltages and currents in the satellite.

For more information, contact the satellite and science experiment principal investigators:

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Designing High-Speed Vehicles for the U.S. Air Force

The High-Speed Vehicle Design Group (HSVDG) of the Aeronautical Research Center (ARC) of the USAFA is involved in a wide variety of activities that support the design of high-speed vehicles, many of which will be part of the 21st century inventory of the USAF. The HSVDG includes several cadets working together with DFAN faculty on a variety of projects.

Nine cadets supported the Air University's Program: "Air Force 2025" by working a study meant to address these questions: "What Air Force Missions are Best Accomplished by Hypersonic Vehicles?" and "What Vehicles Might Be Developed to Accomplish These Missions?" The cadets proposed an integrated weapons system featuring a global-reach/global-power aircraft capable of reaching any point in the world within hours without relying on foreign bases and delivering either hypersonic cruise missiles at extremely high-value targets or serving as the first stage of a two-stage-to-orbit space access system. More specifically, the global-reach hypersonic aircraft would be able to deliver hypersonic cruise missiles anywhere in the world in a matter of hours, operating from bases in the continental U.S. Thus, it would be able to deliver decisive blows at the outset of hostilities, with the goal of destroying the adversary's desire to fight a protracted war, or deliver cost-effective weapons to defeat time critical targets and to establish in-theater dominance, if a protracted war cannot be avoided. The ability of the combined weapons system being able to strike targets anywhere in the world within hours without the need for forward basing generates savings in time and money that justify the cost of designing, building, and deploying the weapons system. The access-to-space missions would also be conducted during peacetime to develop operational procedures, which can be applied to war-time operations should hostilities break out.

The hypersonic aircraft, was designated the Supersonic/Hypersonic Attack Aircraft, or SHAFT, shown in Figure 1, and the hypersonic cruise missile, shown in Figure 2, was designated the Standoff Hypersonic Missile with Attack Capability, or

SHMAC: so what could be more a appropriate motto for this weapons system than "When the SHMAC hits DFAN"?

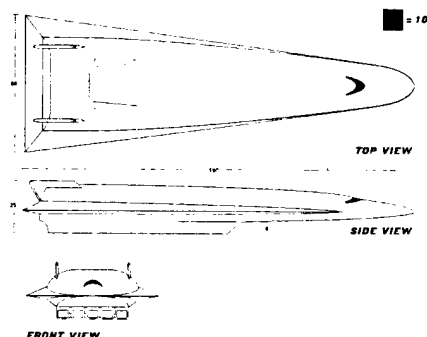


Figure 1. Conceptual design, developed by cadets, of a supersonic/hypersonic Attack Aircraft (SHAFT)

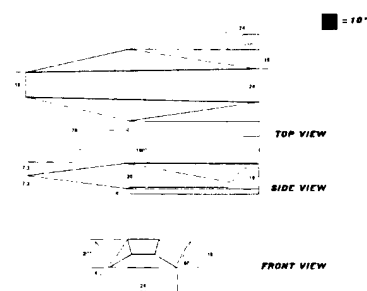


Figure 2. Conceptual design, developed by cadets, of a Stand-off Hypersonic Missile with Attack Capability (SHMAC)

The mission and vehicle configuration concepts developed by the cadets contain many of the features that would be incorporated into the design of a hypersonic weapon system. Indeed, the results of the study were published in the "Air Force 2025" documentation and which were presented by the then 2nd Lieutenants at the AIAA 7th International Space Planes Conference on which was held in Norfolk, VA in November 1996. Large sections of this study were excerpted verbatim and reproduced in a recently published volume, *Stealth Aircraft of the U. S. Air Force*.

Currently active in the research activities of the HSVDG are C1C Evan Gallegos, C1C Tim Pesek, Lt. Col. Steve Pluntze, Maj. Scott Morton, Capt. Jim Forsythe, Capt. Colin Tucker, Capt. Matt Zuber, and Dr. John Bertin. They receive support in the building and the

testing of models in the Tri-Sonic Wind Tunnel (TWT) from Bobby Hatfield, Tim Hayden, Larry Lamblin, and Jim Philp. This research team integrates measurements made in the TWT with flowfield parameters computed using available Computational Fluid Dynamics (CFD) codes to develop an understanding of the flowfields for future weapons systems. The experimental data include global parameters, such as force and moment measurements, local parameters, such as static pressures measured at specific locations on the model, and flow visualization data, such as schlieren photographs and surface oil-flow patterns.

One current project, which is funded through the Air Force Research Laboratory at Eglin AFB, seeks to develop an understanding of the complex flowfield that results when reaction control jets are used to maneuver asymmetric missile configurations. Reaction control jets can be used to produce spectacular maneuvers ("Check your six!"). However, the jet plume creates significant perturbations to the flowfield, resulting in locally severe heat-transfer rates and in locally high pressures. These perturbations must be understood and controlled, if the designers are to use these jets successfully.

Dr. Bertin has been invited to give a paper describing some of the team's activities to the JFASS 13th International Sessions in the 37th Aircraft Symposium to be held in October 1999 in Tokyo Japan. The paper will review the results from four different recent, research programs in which measurements from wind-tunnel programs were compared with the corresponding parameters generated using state-of-the-art CFD codes to evaluate the effect of grid-spacing on the computed solutions, to evaluate the degree of rigor required in developing numerical tools, to better understand the physical phenomena depicted by the data, and to develop a better understanding of the complex hypersonic flowfields on the design of future vehicles.

In addition to using existing computational codes to support the design activities of the HSVDG, the faculty interested in CFD are working to

develop better numerical models to represent various fluid-dynamic phenomena and to develop improved numerical schemes for generating flowfield solutions. These Academy researchers are working to provide

improved tools to the designers of future Air Force weapons systems.

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Department Research News

Department of Astronautics

Lunar Transfer Trajectory Research

The USAFA has been conducting research on a new spacecraft trajectory over the past several years. This new trajectory, a ballistic lunar transfer (BCT), allows spacecraft to be sent to the Moon using less fuel than traditional transfers. Future missions to the moon could implement this method to help make the spacecraft smaller or increase the payload. However, finding the possible BCT's for a given mission is very difficult to do, which can cause this trajectory option to be ruled out early in the design process. Also, the amount of fuel needed to make correction burns during the transfers is currently difficult to estimate. The fuel needed for a theoretical transfer can be calculated fairly easily once a BCT is found, but due to many different error sources, extra fuel is necessary for trajectory corrections along the way.

Research in the Department of Astronautics has dealt with finding these BCT's and determining how much fuel is needed for corrections. The most progress so far has been in the area of finding the orbits, given an initial date. Although analytic solutions have proven to be too complex so far, numerical analysis of several thousand orbit integrations has allowed some general characteristics of these orbits to be revealed. These characteristics help a great deal in generating potential mission BCT's.

Department of Behavioral Sciences and Leadership

Human Factors and Simulation

LCDR Russell Shilling (USN) was elected to Chair the DoD Human Factors Engineering Technical Advisory Group (DoD HFETAG), a three year commitment. He will take over the Chair position in May 1999. The DoD HFETAG is responsible for coordinating Human Factors Engineering Research projects and fostering cooperative research between the Army, Navy, Air Force, FAA, and NASA. He has also been awarded \$15K from the Office of Naval Research to help develop spatialized (3-D) auditory displays for a virtual environments Surface Warfare trainer under development at the Naval Air Warfare Center Training Systems Division in Orlando, FL. LCDR Shilling is writing a chapter for a Virtual Environment's Handbook in collaboration with Dr. Barbara Shinn-Cunningham at Boston University. Through various collaborations, LCDR Shilling has sent cadets on Summer Research to the Naval Aerospace Medical Research Labs and the Naval Postgraduate School. This summer cadets will be sent to the Naval Research Laboratories and the Naval Air Warfare Center Aircraft Division in Patuxent, MD.

Maj Joey Hickox is working with Dr. Jim Barker (DFM) and Brooks AFB in a collaborative effort to examine team performance issues in command and control situations. He has been awarded \$27K in the last two years to establish a new team performance research laboratory here at USAFA. In his second study using an AWACS type control simulation (three-person teams), he is currently examining decision support interfaces, command structure, and information load. Maj Hickox has also been awarded \$10K from AFOSR to examine eye-scanning behavior in expert and novice pilots during tactical VFR navigation. He and C1C Leigh Ottati have just completed the first study and are in the process of analyzing the results to present at the annual meeting of the Human Factors and Ergonomics Society.

Physiological and Performance Psychology

Dr George Mastroianni, Lt Col Bob Berger, Maj Mike Zupan (AH), Maj Pat Bradshaw (DFB), and C1C Jason Zarb-Cousin are working on a project comparing pacing and energy expenditure of runners and mountain bikers on gravel trails at USAFA. With the assistance of Danny Portillo (DFEG), these researchers are using differential GPS to measure speed on terrain segments of varying grade. In conjunction with heart rate monitoring, these measurements will make possible a detailed comparison of the voluntary work rates of runners and bikers on uphill and downhill segments of varying grade. Analyses may suggest pacing strategies to optimize speed and energy expenditure on complex terrain. Additionally, Dr Mastroianni has been awarded \$22.5K from the Soldier Systems Center, US Army Soldier Biological and Chemical Command, to fund research comparing voluntary pacing of individuals with and without backpack loads on hilly terrain. This research will use techniques currently being developed at the USAFA.

Assessment and Attitudinal Research

Col David Porter has been conducting research on institutional assessment techniques involving faculty and cadets, primarily using Peter Senge's "Learning Organization" as a model for integrating the development and assessment of educational outcomes with the values of higher education. Lessons learned from this line of inquiry include the following: diverse perspectives and positions enhance assessment effectiveness; knowledge, skills and attitudes are all important and measurable; imperfection is an inherent characteristic of measuring meaningful outcomes; ease of measurement is usually inversely proportional to significance; group work is not a pedagogical panacea; and convergence provides the best foundation for validity.

Maj Kristen Vance has been studying the dynamics of prejudice, with a specific focus on understanding the process

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by which people reduce prejudiced behavior. Maj Vance investigates variables which promote prejudice reduction and variables which hinder prejudice reduction. She has also launched a research program to examine the predictors and consequences of achievement goals in leadership positions.

Maj Randy Gibb is currently working on a project regarding self-efficacy. His research involves surveying cadets participating in boxing, wrestling, swimming, and women's self-defense. A pre-test, post-test, and post-post-test survey is the procedure. Each survey consists of 28 questions with different sub-groups of self-efficacy questions: physical, assertiveness, coping, determination, and leadership. Maj Gibb is also working on a proposal for AETC funding to research airmanship while in pilot training in both Naval and Air Force training programs. The research will be completed while at the Naval War College.

Department of Foreign Languages***Air Force Language Link - On-Line Russian Language Maintenance and Development***

The On-line Russian Language Maintenance and Development, superintended by Major Stanley Supinski, employs three common educational and communication technologies--the internet, compact disk, and email -- to explore the feasibility of conducting Russian Language maintenance and development in a distance learning mode. Thirty subjects across the Air Force--from Misawa AB, Japan to Langley AFB, Virginia--and several who are deployed or TDY (Bosnia, Vicenza, and others), are participating in the 24-week course. The students will work in cooperative teams of five, using interactive courseware obtained primarily from a CD. They will also interact with each other and a native-Russian course moderator located in Colorado Springs, as well as receive additional, dynamic lessons from a course bulletin board. This truly virtual classroom and course should make optimal use of these technologies while reducing the need to send personnel for expensive in-residence courses. The course also supports the Air Force strategy of "Global Engagement" by increasing Foreign Area Officer and other linguists' Defense Language Proficiency Test scores. The study and course will be completed in July 1999.

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Department of Foreign Languages

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